Determination of Concentrations of Sulphur Dioxide at Major Stalling Traffic Points in Minna, Niger State, Nigeria

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Abstract
This project was undertaken to determine the concentrations of sulphur dioxide (SO_2) at the different major stalling traffic points in Minna and to create a Geographic Information System (GIS) layer of SO_2 pollution at these stalling traffic points; forty (40) such major stalling traffic points were identified in Minna. These major stalling traffic points of Minna were initially georeferenced, the values archived on the Minna GIS, and then SO_2 levels were measured at some of these stations during the morning, afternoon, and evening hours. The dataset acquired for this survey indicates that no value of SO_2 up to and above the threshold of 0.2ppm was measured at any of the stalling traffic points occupied in the course of this survey. Thus, for the time of day when traffic warden personnel are active in Minna (morning and afternoon hours) none of them would be exposed to hazardous levels of SO_2 emissions; if they were to work into the evening hours, the exposure regime would be unchanged. The final result of this exercise is now a GIS SO_2 level layer at stalling traffic points in Minna.

Keywords: Stalling traffic, GIS layer, georeference, emission index

INTRODUCTION

Sulphur (IV) dioxide pollution is a constant menace facing the typical traffic warden at any of the major stalling traffic points in Minna (Jonah et al., 2010). Knowing the level of exposure to this kind of noxious emission should be of interest to the traffic warden personnel and the overseeing authority charged with public health issues, that is, the Niger State Environmental Protection Agency (NISEPA). This study was undertaken with such a target objective in mind (the "target" being the cataloguing of SO_2 emission indices at the major stalling traffic points in Minna; the "objective" would be the inauguration of a public enlightenment programme as a result of the availability of an emission index profile). Furthermore, as a result of the current trend in handling georeferenced data, the dataset of this study was processed and displayed in conformance with the Geographic Information System (GIS) scheme.

Concept of Stalling Traffic Point: For this study, a "stalling traffic point" is defined to be a road junction or node where all practical motor-mobiles (i.e. cars, trucks, motor-tricycles, motor-cycles, etc.) necessarily decelerate upon approaching the junction, for practical safety purposes, and accelerate to change velocity as they exit that junction; the process of acceleration involves a revving of the engines of the motor-mobiles, with associated increase in the exhaust gaseous effluents. Thus, stalling traffic points are formed at intersections of road junctions and major stalling traffic points are formed at intersections of major road junctions.

Concept of Parts Per Million (ppm): The parts per million (ppm) is commonly used as a measure of small levels of pollutants in air, water, body fluids, etc. Parts per million is the mass ratio between the pollutant component and the solution and ppm is defined as a way of expressing very dilute concentrations of substances. Just as per cent means out of a hundred, so parts per million or ppm means out of a million. One ppm is equivalent to 1 milligram of something per liter of water (mg/l) or 1 milligram of something per kilogram soil (mg/kg).

Sulphur Dioxide Essentials: According to Raymond and Brandon (1981), sulphur (IV) dioxide is formed when sulphur burns in air:

$$S(s) + O2(g) \rightarrow SO2(g) \quad (1)$$

Sulphur dioxide is a pungent, colourless gas that is quite toxic. Sulphur dioxide reacts with water to give the corresponding acids:

$$2SO_2(g) + 2H_2(1) \leftrightarrow 2H_2SO_3(1) \quad (2)$$

Sulphur dioxide is a pungent, colourless gas that is quite toxic. Sulphur dioxide reacts with water to give the corresponding acids:

$$2H_2SO_3(1) + O_2(g) \rightarrow 2H_2SO_4(1) \quad (3)$$

Else, SO_2 can be oxidized to a secondary pollutant, SO_3, in the presence of oxygen, sunlight, and water vapour:

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g) \quad (4)$$

When SO_3 is dissolved in water, sulphuric acid is formed

$$SO_3(g) + H_2O(1) \rightarrow H_2SO_4(1) \quad (5)$$

There are several sources of atmospheric SO_2: nature itself contributes much SO_2 in the form of volcanic eruptions. Also, many metals exist combined with sulphur in nature (e.g. zinc as sphalerite, ZnS and iron as pyrite, FeS_2). Extracting the metals often entails smelting or roasting the ores, i.e. heating the metal sulphide in air to form the metal oxide and SO_2. For example:

$$2Z_nS(_s) + 30_2(g) \rightarrow 2Z_nO(_s)+2SO_2(g) \quad (6)$$

Although smelting is a major source of SO_2, the burning of fossil fuels in industry, in power plants, and in homes accounts for most of the SO_2 emitted to the atmosphere. The sulphur content of coal ranges from 0.5 to 5 percent by mass, depending on the source of the coal. The sulphur content of other fossil fuels is similarly variable. Oil from the Middle East, for instance, is low in sulphur, while that from Venezuela has high sulphur content. To a lesser extent, the nitrogen-containing compounds in oil and coal are converted to nitrogen oxides, which can also acidify rain water. All in all, some 50 million to 60 million tons of SO_2 are released into the atmosphere each year (Amdur, 1989; Montgomery, 1995). In the troposphere, SO_2 is almost all oxidized to H_2SO_4 in the form of aerosol, which ends up in wet precipitation or acid rain. At the present, there exist no specific studies targeted at understanding the factors that contribute negatively to impact the health of traffic warden personnel at Minna. These traffic warden personnel spend almost all their active working hours at the stalling traffic points of Minna town.

The objectives of this study are as follows:

i. To measure sulphur dioxide emission levels at stalling traffic points with a view to determining if traffic warden personnel at these stalling traffic points are exposed to high levels of this gas or not.

ii. To create a Geographic Information System (GIS) layer of sulphur dioxide emission levels at these stalling traffic points for Minna town. Naturally, such a sulphur dioxide emission level GIS layer is substrated upon the existence of a GIS database for Minna.

Abbey et al (1993) reported a study on Seventh-Day Adventist (SDA) non-smokers who had resided since 1966 within five miles of their residence. The authors completed a standardized respiratory symptoms questionnaire in 1977 and again in 1987. For each participant, cumulative ambient concentrations from 1977 to 1987 of suspended sulphates (SO_4) in excess of several cutoffs as well as mean concentrations were estimated by interpolating monthly ambient concentration statistics from state air monitoring stations to the individual's residential and workplace zip codes. There were significant associations between ambient concentrations of suspended sulphates and development of new cases of asthma, but not new cases of overall airway obstructive disease (AOD) or chronic bronchitis. Comparison of previous analyses, in this population, of respiratory disease symptoms and total suspended particulates (TSP), ozone, and sulphur dioxide (SO_2), and multipollutant analyses of these pollutants with SO_4, indicated that these results were not due to a surrogate relationship with other air pollutants. Development of definite symptoms of AOD and chronic bronchitis was found to be most strongly related to TSP.

Amdur (1989) discussed a study on data collected from exposure of experimental animals and human subjects to sulphuric acid that presents a consistent picture of its toxicology. Effects on airway resistance in asthmatic subjects were well predicted by data obtained on guinea pigs. Sulfuric acid increases the irritant response to ozone in both rats and man. In donkeys, rabbits, and human subjects, sulfuric acid alters clearance of particles from the lung in a similar manner. These changes resemble those produced by cigarette smoke and could well lead to chronic bronchitis. Data obtained on guinea pigs indicated that very small amount of sulfuric acid on the surface of ultrafine metal oxide aerosols produce functional, morphological, and biochemical pulmonary effects. Such particles are typical of those emitted from coal combustion and smelting operations.

Bates (1995) remarked that a review of the present understanding of asthma leads to the following conclusions: associations between indices of health effects and air pollutants indicate that these are probably playing a role in the worsening of asthma. Adverse effects related to SO_2 exposures have also been documented.

The creation of a sulphur dioxide emission level GIS layer at stalling traffic points for Minna town would contribute immensely to the public health repository database of the Niger State Government. Such a database would form a critical component of the public health policy formulations of the Niger State Government. Also, Jonah et al (2009; 2010) have built frameworks for sulphur dioxide pollution studies and they have always recommended continuous sulphur dioxide monitoring studies and mitigation schemes.

The Area of Study: This study is centred on Minna town, the stations of interest being the major stalling traffic points: forty (40) such locations have been identified. These are Jafar Mairiga Junction, F.U.T. Minna Junction, Mypa Junction, Bahago Junction, Zarumai Roundabout, Government House Junction, Mustapha Junction, Government Day Junction, Emir's Palace Junction, Kuta Road/Obasanjo Complex Roundabout, Unity Bank Junction, Mobil Roundabout, I.B.B. Road Roundabout, Central Bank Junction, F.R.S.C. Junction, David Mark Road Roundabout, N.S.T.A. Junction, MTN Junction, Top Medical Junction, Muazu Babangida Junction, Abdulsalam Motor Park Junction, Royal Wood/Conoil Junction, City Gate Roundabout, Mandela Road/Talba Farm Junction, Shiroro Hotel Junction, Morris Fertilizer Junction, Kpakungu Roundabout, Cemetery Roundabout, Kure Modern Market Junction, Federal Secretariat Junction, Dutsen Kura Junction, Arayan Junction, London Street Junction, Okada Road Junction, General Hospital Junction, Sabon Gari Junction, Peda Junction, Kuta Motor Park Junction, Flamingo Junction, and Dana Pharmaceutical Roundabout. These major stalling traffic points are, for practical purposes, not evenly-spaced but are easily identified within the Minna built-up town centre. As expected of a typical traffic node, motor-mobiles are the primary sources of SO_2 at these locations. The Minna built-up town centre (from the Maryam Babangida Girls Science Secondary School in the north to the Abdulkareem Lafene State Secretariat in the south, and the southwest-northeast Kpakungu-Maitumbi axis), was covered for this study.

Survey Procedures

Site Selection: The areal extent of Minna town was earmarked for this survey, initially to cover all of Maikunkele to Chanchaga and all of the outlying neighbourhoods of Kpakungu to the outlying neighbourhoods of Maitumbi. However, because of the need to create a Geographic Information System (GIS) layer of sulphur dioxide signature substrated on an existing Minna GIS, and because the existing Minna GIS was substrated on the acquired analogue map of Fig. 1 the areal extent selected for this study covered the Maryam Babangida Girls Science Secondary School in the north to the Abdulkareem Lafene State Secretariat in the south, and the southwest-northeast Kpakungu-Maitumbi axis.

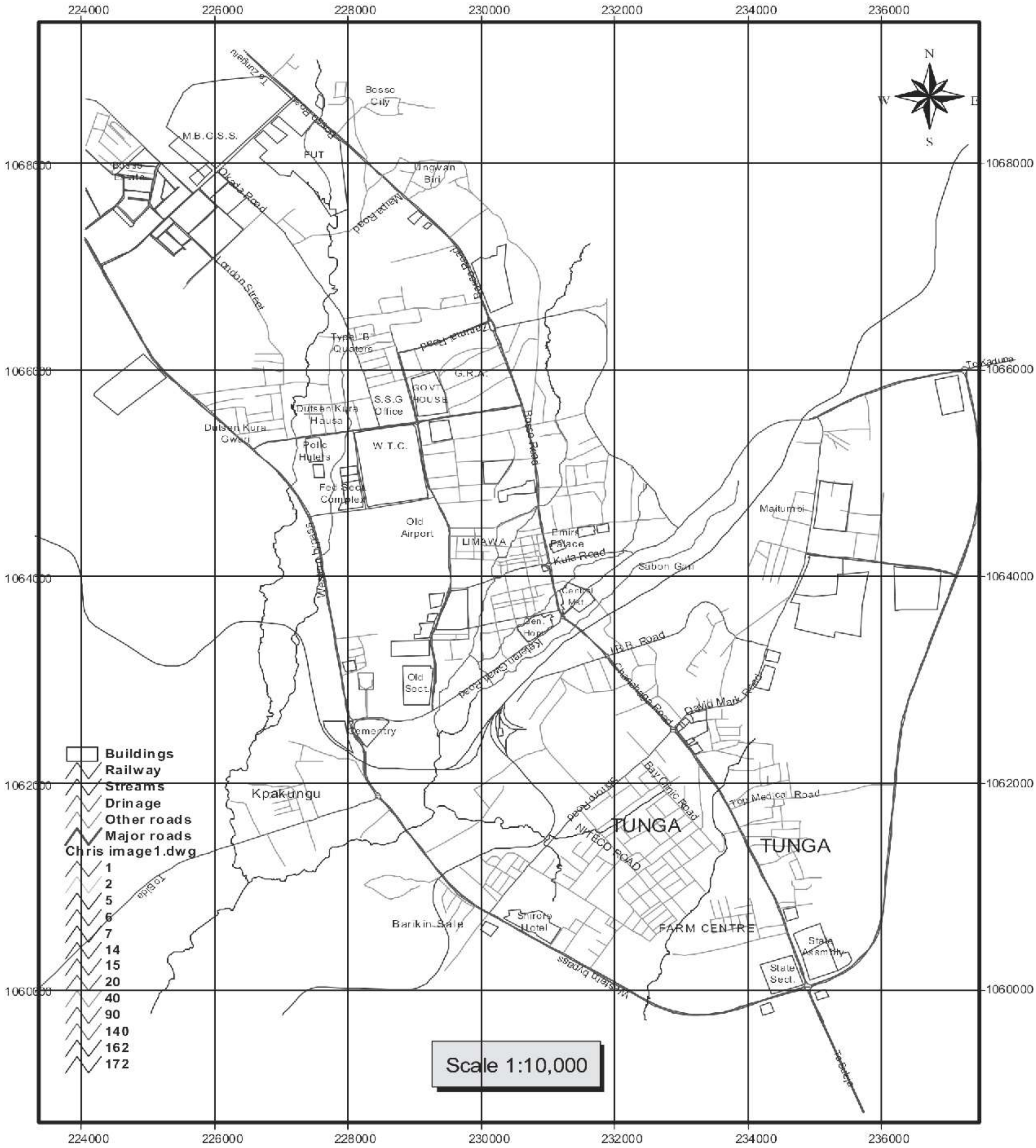

Fig. 1 Analogue map of Minna (Source: Datanet Services)

Survey Tools: Field Compass; The common field compass was used extensively during the course of this survey as a key direction-finder. Since the map of Fig.1 has a directional icon indicating the four cardinal points, the compass enabled the survey party to confirm that the vicinity of Maryam Babangida Girls Science Secondary School (the most northern of the stations of interest) is truly northward of the staging or muster point for this survey, i.e. the Federal University of Technology, Minna's Bosso Campus. The compass was also used in tandem with the hand-held Global Positioning System (GPS) unit to eliminate any doubt whatsoever as to whether the study group members were on an exact straight course, when this information was desired.

Hand-held Global Positioning System (GPS) Unit; The Garmin etrex hand-held Global Positioning System (GPS) unit was employed chiefly for georeferencing of stations of interest during the course of this survey; it was also used in tandem with the field compass, for a minor role sort of, to confirm a defined "rectilinear" direction. Actually, the aforementioned existing Minna GIS, specific to this study, was created by reliance on georeferencing information acquired by means of the Garmin etrex hand-held (GPS) unit, thus ensuring a modicum of fidelity.

Sulphur Dioxide Meter; The sulphur dioxide meter employed for this survey was the CROWCON GASMAN SO_2 meter.

Sulphur Dioxide Measurements at Stalling Traffic Points: A measurement using the SO_2 meter proceeded by occupying the first georeferenced road stalling traffic point for this survey, namely the road junction opposite the Ja'afaru Mairiga Motel. Initially, the SO_2 meter was turned on (i.e. by pressing down the large power button) whence the device went through some self-test routines like alarm test, LCD test, and battery level test. After the entire test the SO_2 reading for that particular place was displayed numerically on the LCD screen. At each of the stalling traffic point of interest, three different values of the SO_2 level at that instant were measured and recorded; each of these values is the weighted mean of SO_2 level over a time interval, thus ensuring that error is kept to a minimum.

Dataset of Study: The body of acquired data for this study is shown in Tables 1-3.

Table 1: Dataset for morning hours (i.e. interval of 0001-1159 hours)

Station No.	Conventional Location	X-value (UTM)	Y-value (UTM)	Average SO_2 Value (ppm)	SO_2 Level Threshold (ppm)
1	Jafar Mairiga Junction	228437	1068754	0.001900	0.200000
2	F.U.T. Junction	228819	1068379	0.002067	0.200000
3	Maipa Junction	229357	1067847	0.001400	0.200000
4	Bahago Junction	230096	1066785	0.002000	0.200000
5	Zarumai Roundabout	230163	1066569	0.001833	0.200000
6	Government House Junction	230450	1065782	0.001867	0.200000
7	Mustapha Junction	230495	1065592	0.002000	0.200000
8	Government Day Junction	230563	1065262	0.002233	0.200000

9	Emir's Junction	230640	1064527	0.002200	0.200000
10	Kuta/Obasanjo Complex Roundabout	230697	1064238	0.003500	0.200000
11	Unity Bank Junction	230733	1064057	0.003600	0.200000
12	Mobil Roundabout	230818	1063729	0.003667	0.200000
13	IBB Round about	231211	1063359	0.003700	0.200000
14	Central Bank Junction	231416	1063093	0.003733	0.200000
15	FRSC Junction	231649	1062823	0.003533	0.200000
16	David Mark roundabout	231810	1062633	0.003733	0.200000
17	NSTA Junction	232004	1062388	0.003167	0.200000
18	MTN Junction	232045	1062306	0.003267	0.200000
19	TOP Medical Junction	232312	1061850	0.003567	0.200000
20	Muazu Babangida	232408	1061644	0.003533	0.200000
21	Abdulsalam Park Junction	232786	1060830	0.003500	0.200000
22	Royal Wood/Conoil Junction	232828	1060673	0.002633	0.200000
23	Tall gate Round about	232995	1060170	0.002467	0.200000
24	Mandela/Farm Junction	231434	1060097	0.002667	0.200000
25	Shiroro Hotel Junction	230174	1060852	0.003267	0.200000
26	Morris Junction	229616	1061440	0.003433	0.200000
27	Kpakungu Roundabout	229184	1062006	0.002933	0.200000
28	CemSetery Roundabout	228933	1062725	0.003467	0.200000
29	Main Market Junction	228751	1063873	0.003033	0.200000
30	Federal Secretariat Junction	228570	1064679	0.003300	0.200000
31	Dutsen Kura Junction	228065	1065344	0.003633	0.200000
32	Arayan Junction	226707	1067122	0.002333	0.200000
33	London Street Junction	227312	1067596	0.001400	0.200000

Table 2. Dataset for Afternoon Hours (i.e. interval of 1201-1859 hours)

Station No.	Conventional Location	X-value (UTM)	Y-value (UTM)	Average SO_2 Value ppm)	SO_2 Level Threshold (ppm)
1	Jafar Mairiga Junction	228437	1068754	0.003733	0.200000
2	FUT Junction	228819	1068379	0.003533	0.200000
3	Maipa Junction	229357	1067847	0.003467	0.200000
4	Bahago Junction	230096	1066785	0.003667	0.200000
5	Zarumai oundabout	230163	1066569	0.003533	0.200000
6	Government House Junction	230450	1065782	0.003600	0.200000
7	Mustapha Junction	230495	1065592	0.003733	0.200000
8	Government Day Junction	230563	1065262	0.003600	0.200000
9	Emir's Junction	230640	1064527	0.003267	0.200000
10	Kuta/Obasanjo Complex Roundabout	230697	1064238	0.003667	0.200000
11	Unity Bank Junction	230733	1064057	0.003633	0.200000
12	Mobil Roundabout	230818	1063729	0.003633	0.200000
13	IBB Round about	231211	1063359	0.003700	0.200000
14	Central Bank V	231416	1063093	0.003633	0.200000
15	FRSC Junction	231649	1062823	0.003767	0.200000
16	David Mark roundabout	231810	1062633	0.003167	0.200000
17	NSTA Junction	232004	1062388	0.003467	0.200000
18	MTN Junction	232045	1062306	0.003267	200000
19	TOP Medical Junction	232312	1061850	0.002900	0.200000
20	Muazu Babangida Junction	232408	1061644	0.003267	0.200000

Table 3. Dataset for Evening Hours (i.e. interval of 1901-2359 hours)

Station No.	Conventional Location	X-value (UTM)	Y-value (UTM)	Average SO_2 Value (ppm)	SO_2 Level Threshold (ppm)
1	Muazu Babangida Junction	232408	1061644	0.003267	0.200000
2	Abdulsalam Park Junction	232786	1060830	0.002867	0.200000
3	Royal Wood/Conoil Junction	232828	1060673	0.002567	0.200000
4	Tall gate Round about	232995	1060170	0.003067	0.200000
5	Mandela/Farm Junction	231434	1060097	0.003333	0.200000
6	Shiroro Hotel Junction	230174	1060852	0.0035	0.200000
7	Morris Junction	229616	1061440	0.0026	0.200000
8	Kpakungu Roundabout	229184	1062006	0.003067	0.200000
9	Cemetery Roundabout	228933	1062725	0.0026	0.200000
10	Main Market Junction	228751	1063873	0.002933	0.200000
11	Federal Secretariat Junction	228570	1064679	0.0019	0.200000
12	Dutsen Kura Junction	228065	1065344	0.001867	0.200000
13	Arayan Junction	226707	1067122	0.0018	0.200000
14	London Street Junction	227312	1067596	0.001467	0.200000

DATA ANALYSIS AND CREATION OF A GEOGRAPHIC INFORMATION SYSTEM (GIS) LAYER OF SULPHUR DIOXIDE EMISSIONS

Sulphur Dioxide Emission Analysis: For this study, United States Environmental Protection Agency (USEPA) SO_2 level threshold of 0.2 parts per million (ppm) was selected. Average SO_2 levels for the three readings at each of the stalling point were computed and tabulated, see Tables 1-3.

Creation of a Sulphur Dioxide Emission Geographic Information System (GIS) Layer for Major Stalling Traffic Points at Minna: The sulphur dioxide level GIS layer was substrated on the existing Minna Geographic Information System (MGIS). The composite GIS SO_2 level maps for the morning, afternoon, and evening hours at the stalling traffic points are as shown in Figs 2-4.

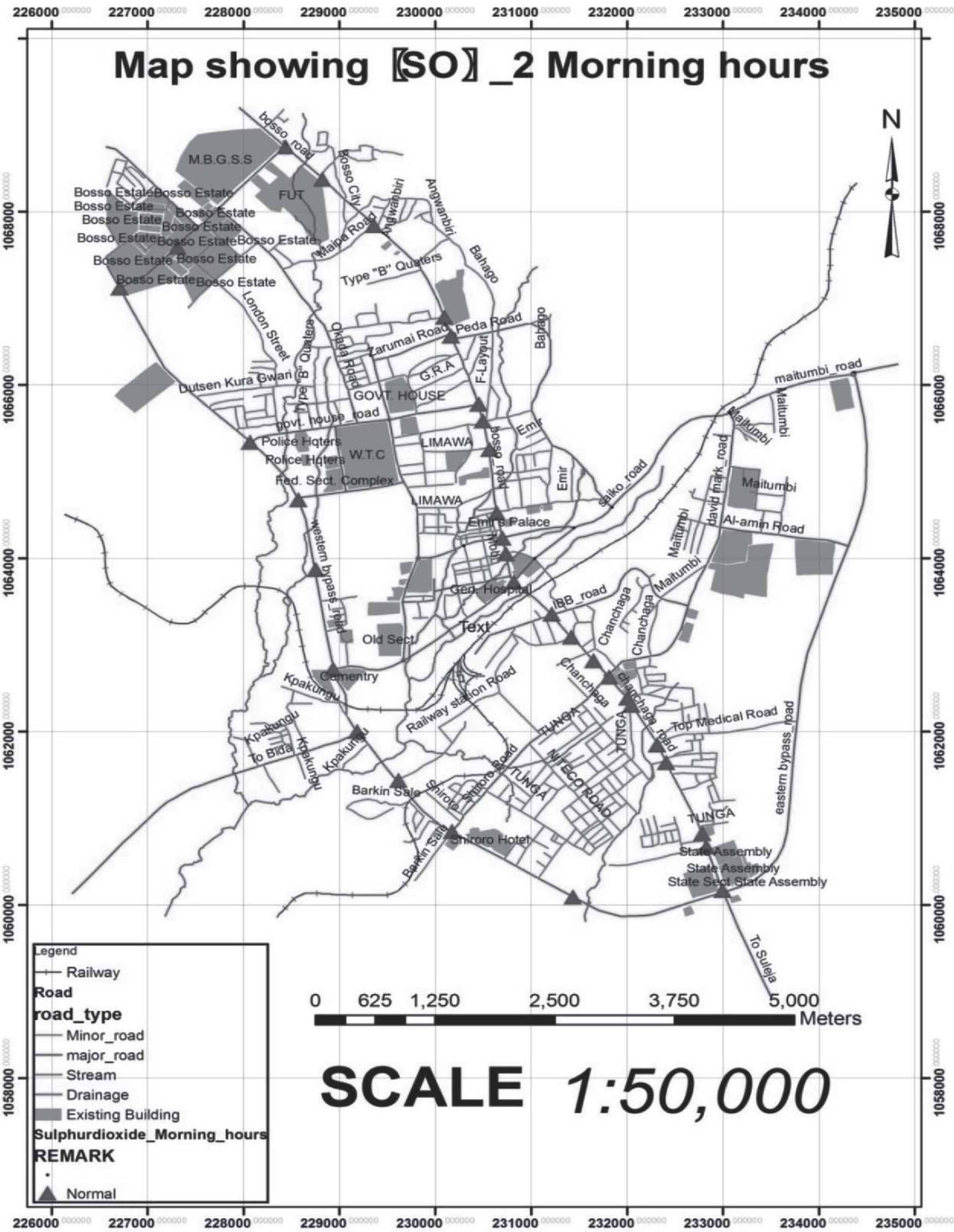

Fig. 2 Composite GIS sulphur dioxide level map for the morning hours. (The blue triangles at the identified major stalling traffic points visited during the morning hours indicate tolerable or "normal" levels of So_2.)

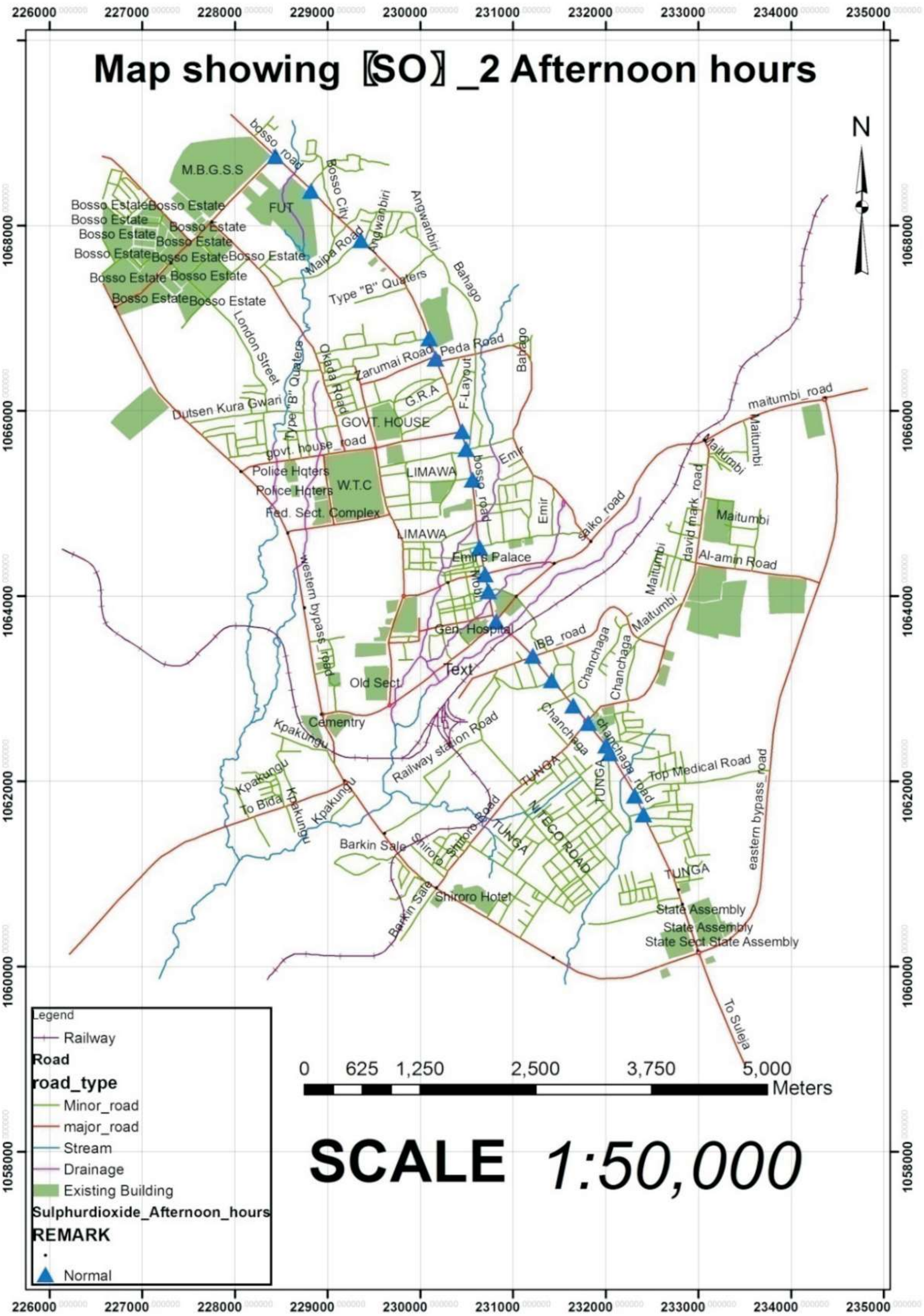

Fig. 3 Composite GIS sulphur dioxide level map for the afternoon hours. (The blue triangles at the identified major stalling traffic points visited during the afternoon hours indicate tolerable or "normal" levels of So_2.)

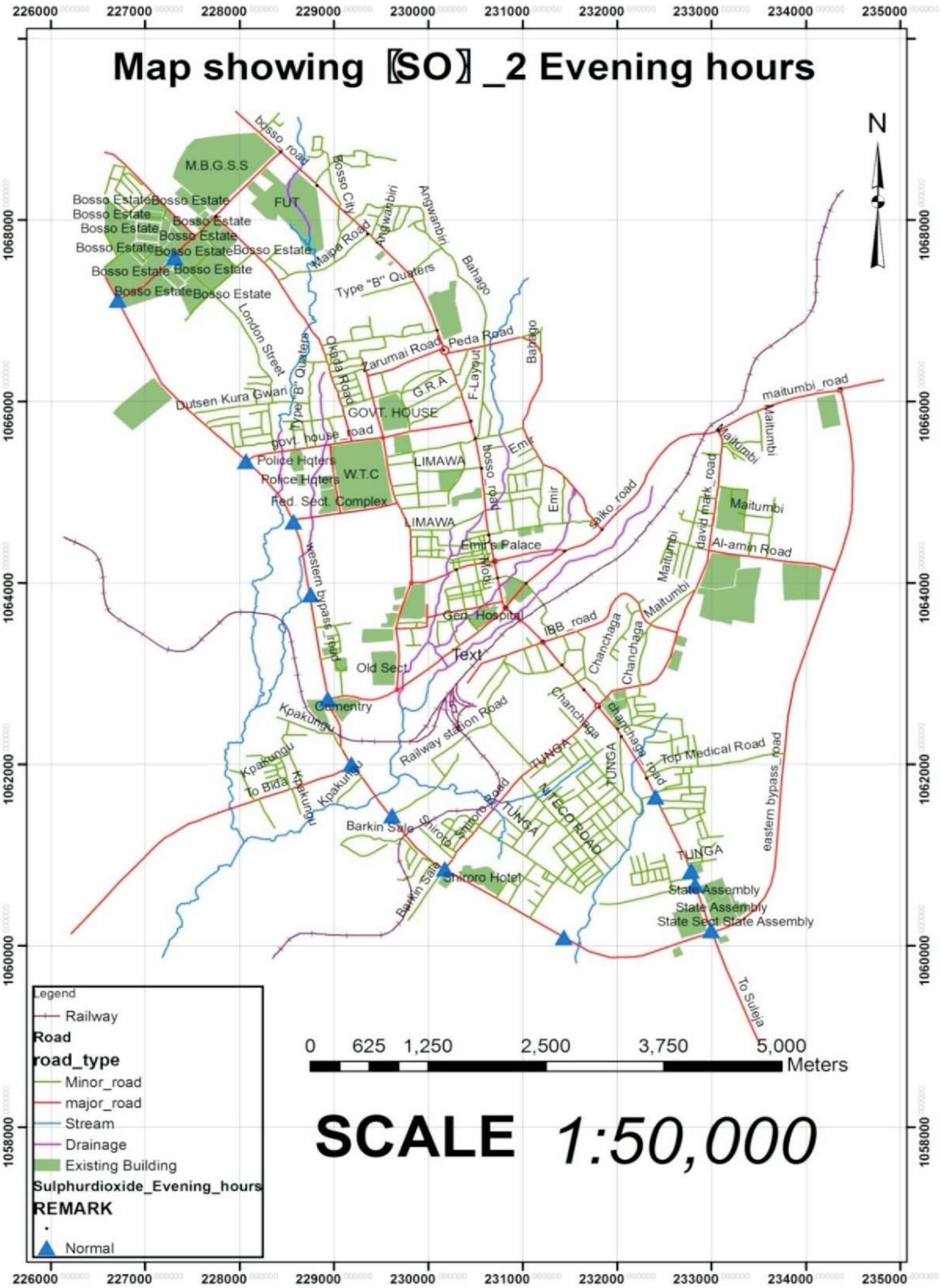

Fig.4 Composite GIS sulphur dioxide level map for the evening hours. (The blue triangles at the identified major stalling traffic points visited during the evening hours indicate tolerable or "normal" levels of So_2.)

DISCUSSION, CONCLUSION, AND RECOMMENDATION

Discussion: The "morning hours" surveys were those carried out between the 00:01a.m.-11:59a.m interval, "afternoon hours" surveys were carried out between the 12:01p.m.-06:59p.m interval and "evening hours" surveys were carried out between the 07:01p.m.-11:59p.m interval. The dataset acquired for this survey indicates that no value of SO_2 up to and above the safe threshold of 0.2ppm was measured at any of the stalling traffic points occupied in the course of this survey. Based on the MGIS, SO_2-level GIS layers for the morning, afternoon, and evening hours were created for the stalling traffic points of Minna that were visited at those times; these are the composite maps of Figs 2-4. SO_2-level indicators are shown as blue triangles at these stalling traffic points on the GIS-layer composite maps: these blue-triangle indicators correspond to values of SO_2 less than the threshold.

Conclusion: The result of this survey shows that for the time of day when traffic warden personnel are active in Minna (morning and afternoon hours) none of them would be exposed to hazardous levels of SO_2 emissions; if they were to work into the evening hours, the exposure regime would be unchanged. Sulphur dioxide exposure at the major stalling traffic points in Minna is nil overall. The final result of this exercise is now a GIS SO_2 level layer at stalling traffic points in Minna. This GIS SO_2 level layer is now a veritable audit mechanism tool for stalling traffic points at Minna.

Recommendation: It is recommended that the result of this survey be archived for future reference purpose and the continual monitoring of sulphur dioxide level.

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